RHIC AC Dipole Preliminary Study

W. Meng

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Requirements:

~100 G-m @ 39 kHz; preferred high Q = R*sqrt(C/L)

(1) Aperture -- limited by ceramic vacuum pipe 4” (ID)
with 0.25” thickness wall $\longrightarrow$ 4.5” (OD) = 11.43 cm

Clear bore: R~6.0 cm

(2) Field quality – low E-3 field errors

Goals: dipole b1 ~ 100 Gauss (Lm = 1 m)
sextupole ratio b3/b1 ~ 1.5E-3 @ R=2 cm
3.4E-3 @ R=3 cm
obey scaling ~ (R/Ro)**2

(All cases in this study are achieved such quality)

Existing AC Dipole – Large current sheet type

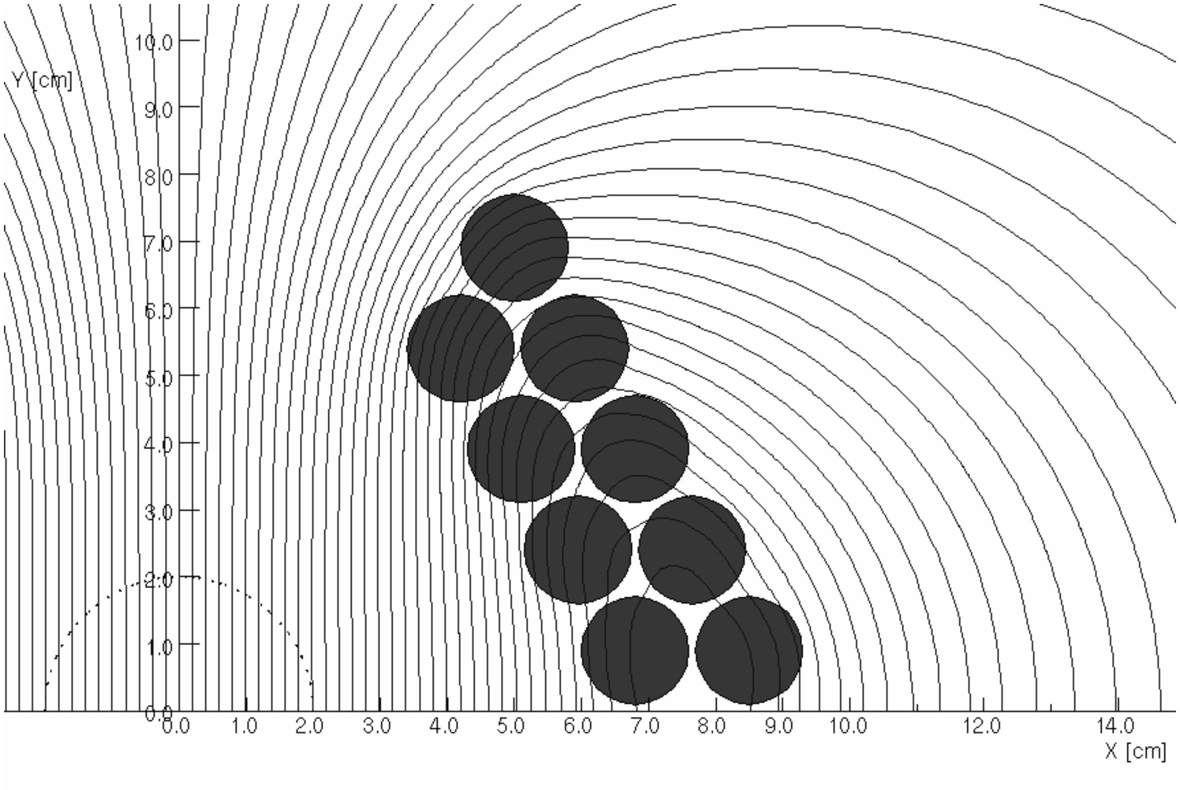
small aperture ~ R=1.5 cm; Io = 79 A

Good field quality (in 2d), but high inductance ~ 104 μH

Scaled from Existing One –

If we use similar conductor, more turns (N=8, or 9) are needed to build up enough height to achieve field quality.

Scaled from existing one – Air-coil



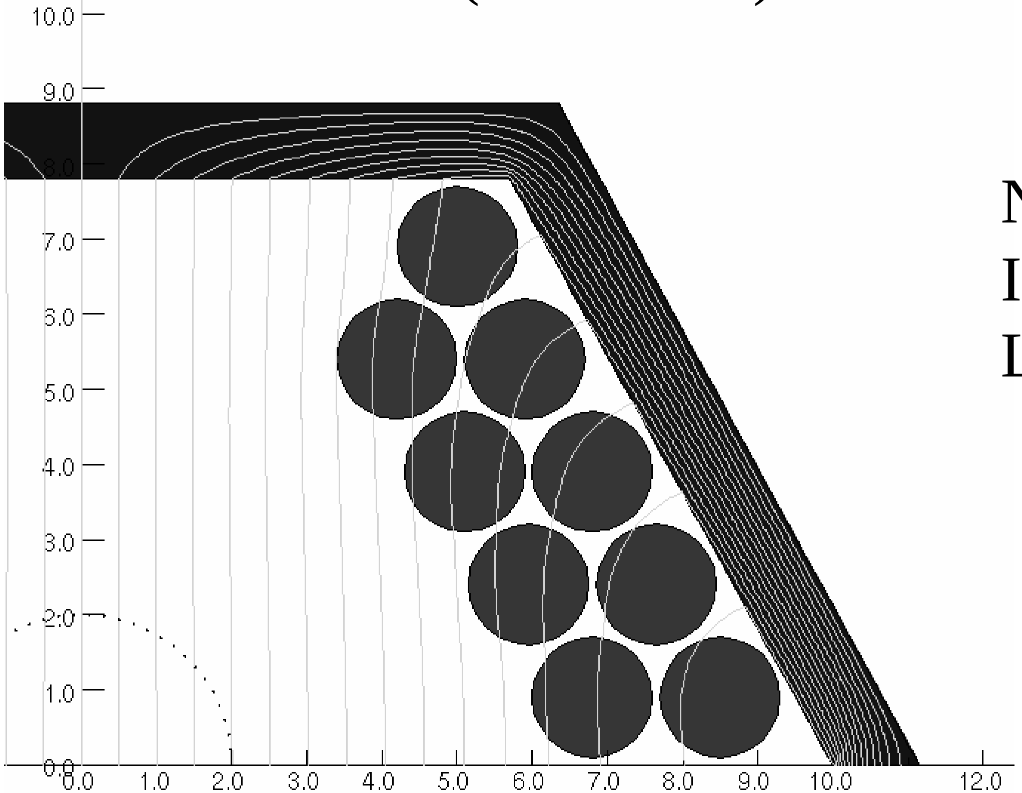
N = 9 (x2)

Io = 127.15 A

L = 153.7 μH

(per magnet with L_m=100 cm)

Scaled with Ferrite (CMD5005)



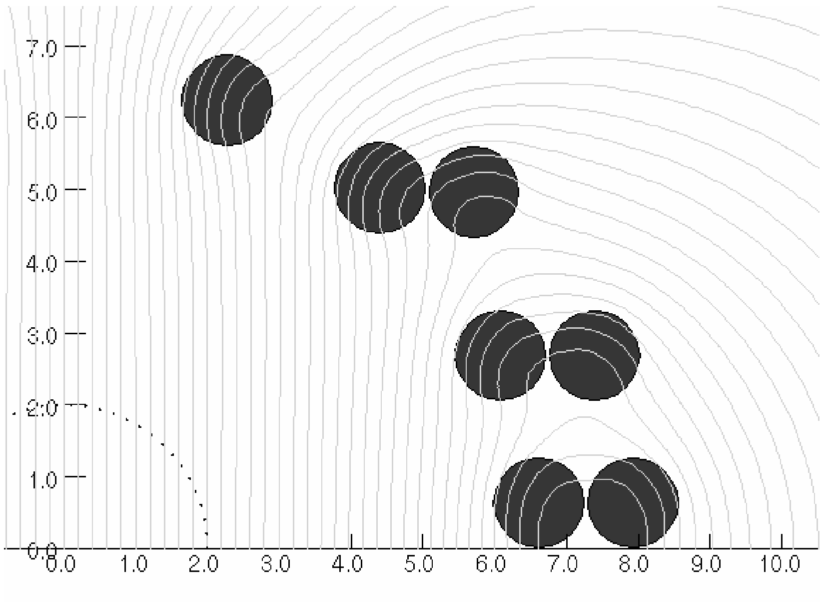
N = 9 (x2)
Io = 69.7 A
L = 296.4 μH

Turns/Inductance can be reduced if special conductors (laminated Sheet?) are used. (Req. further research)

Cu skin depth: d = 0.33 mm @ 39 kHz

Cosine Theta Type -- N = 7 (x2) Air-coil

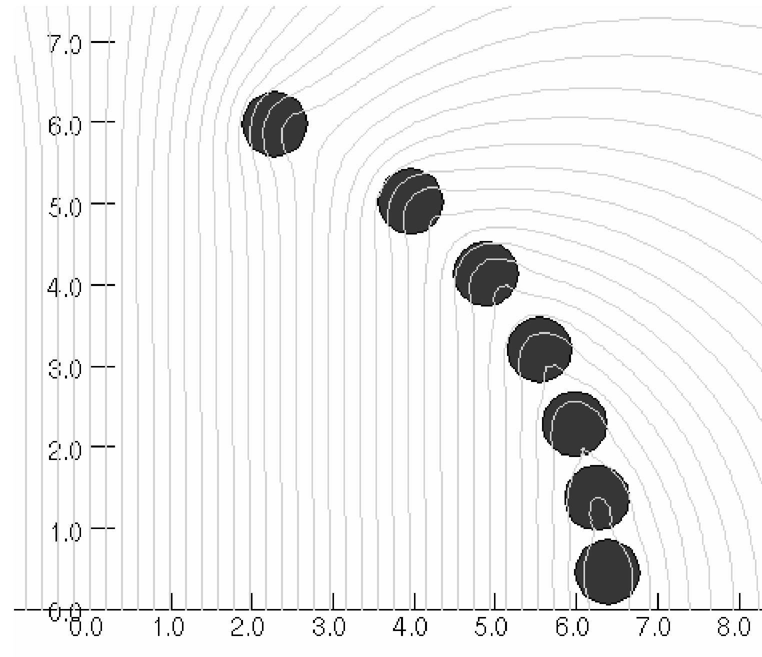
Two-layer



Io = 162.7 A

L = 90.7 μH

One-layer (small conductor)

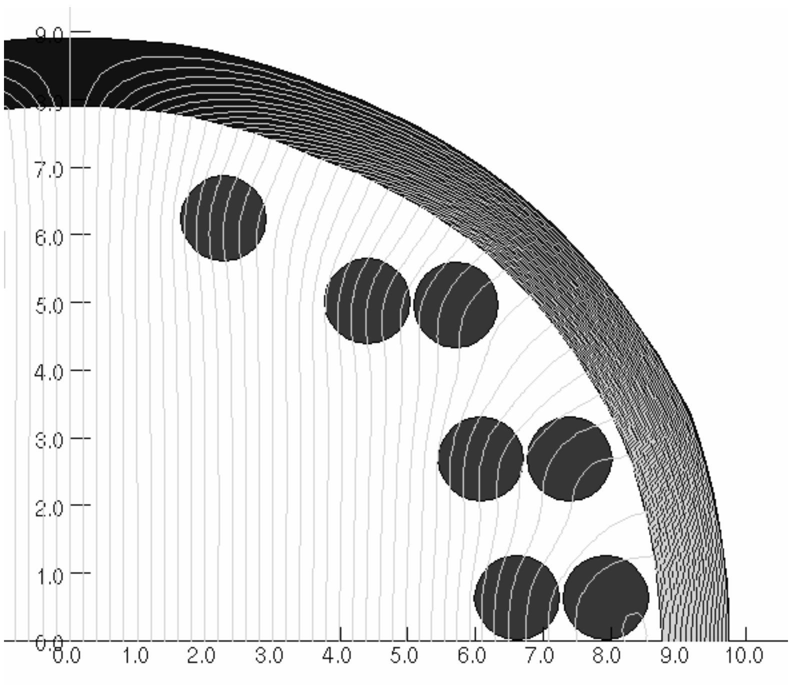


Io = 149.7 A

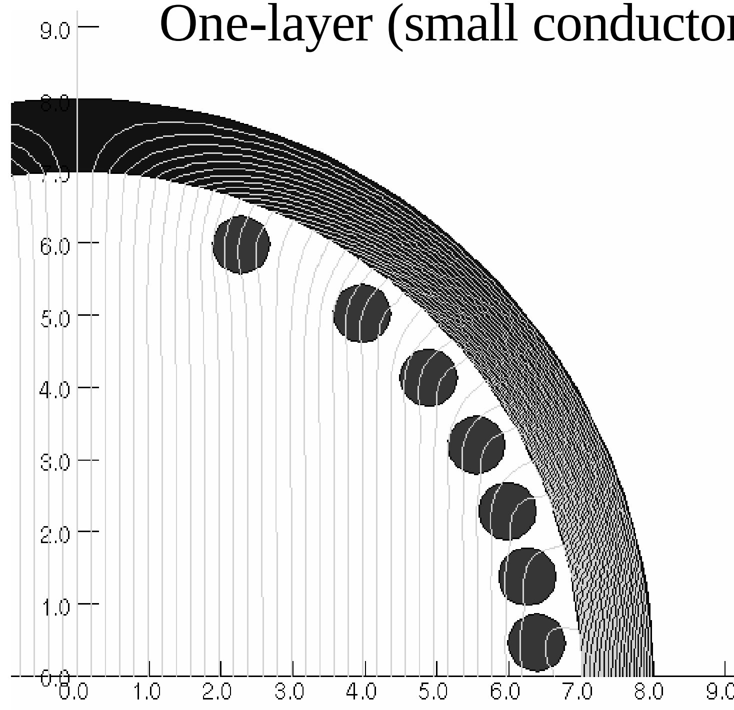
L = 93.3 μH

Cosine Theta Type -- N = 7 (x2) with Ferrite

Two-layer



One-layer (small conductor)



Io = 89.8 A

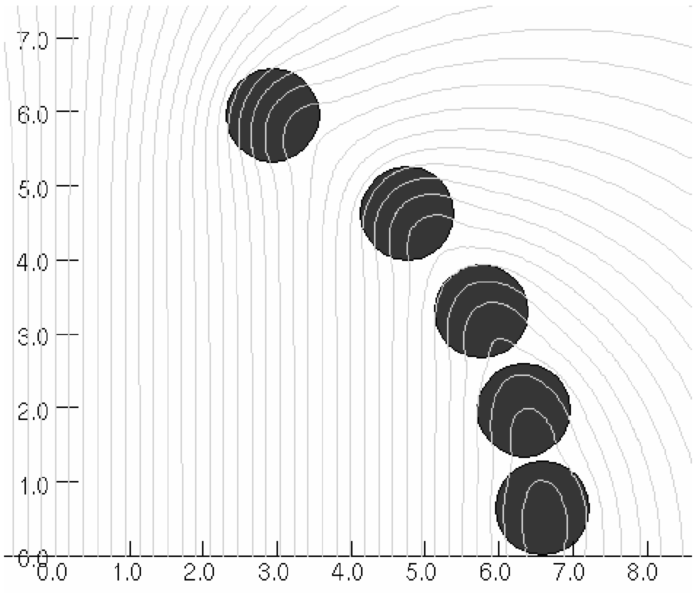
L = 171.1 µH

Io = 79.9 A

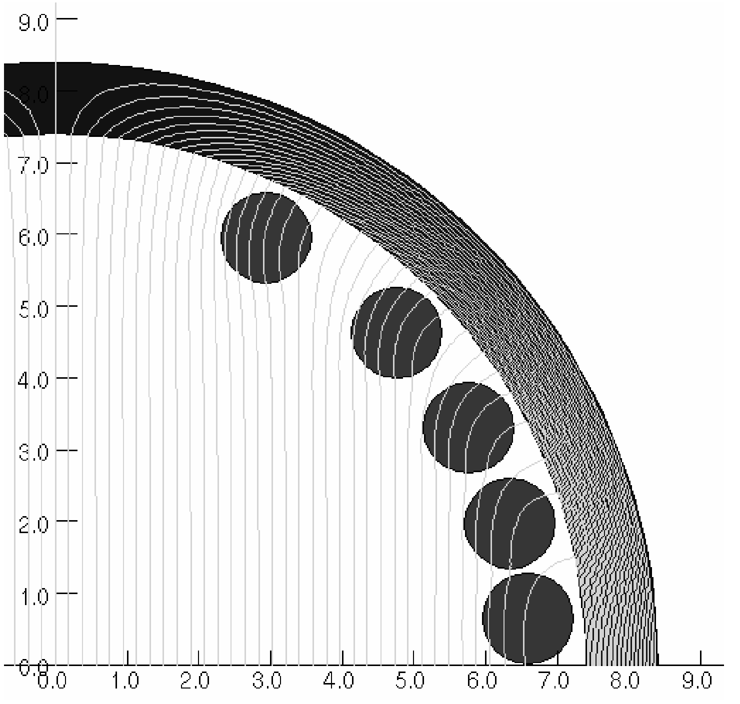
L = 175.8 A

Cosine Theta Type – N=5 (x2)

Air-coil



with ferrite



Io = 223.0 A

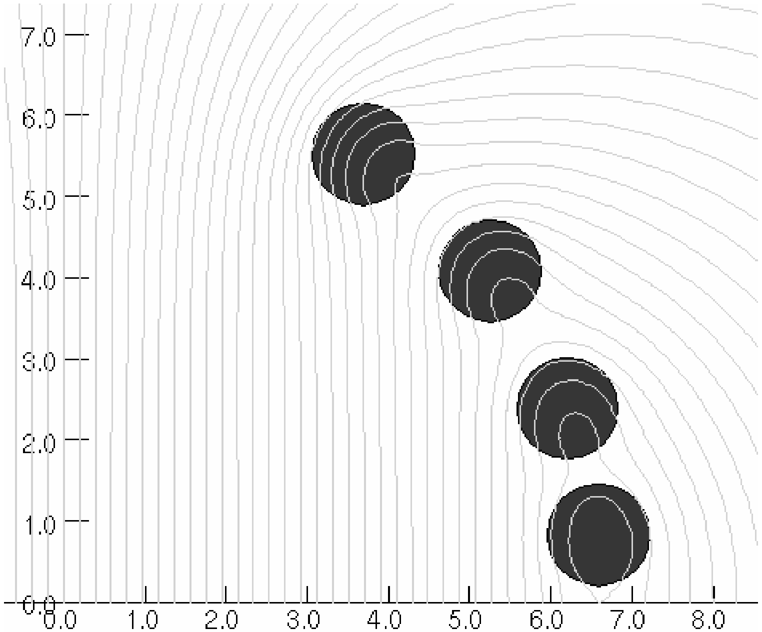
L = 47.53 μH

Io = 122.63 A

L = 88.9 μH

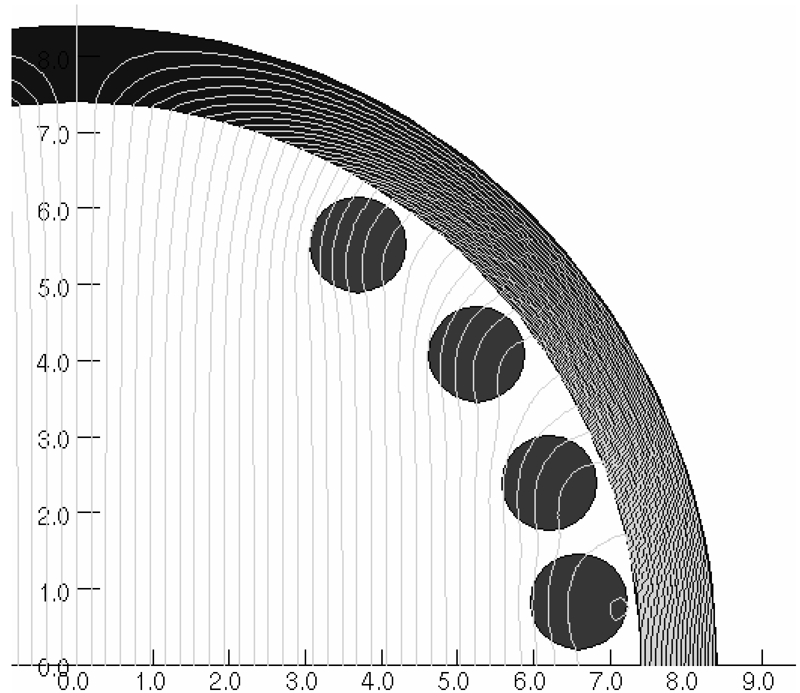
Cosine Theta Type – N=4 (x2)

Air-coil



Io = 264.7 A
L = 32.2 μH

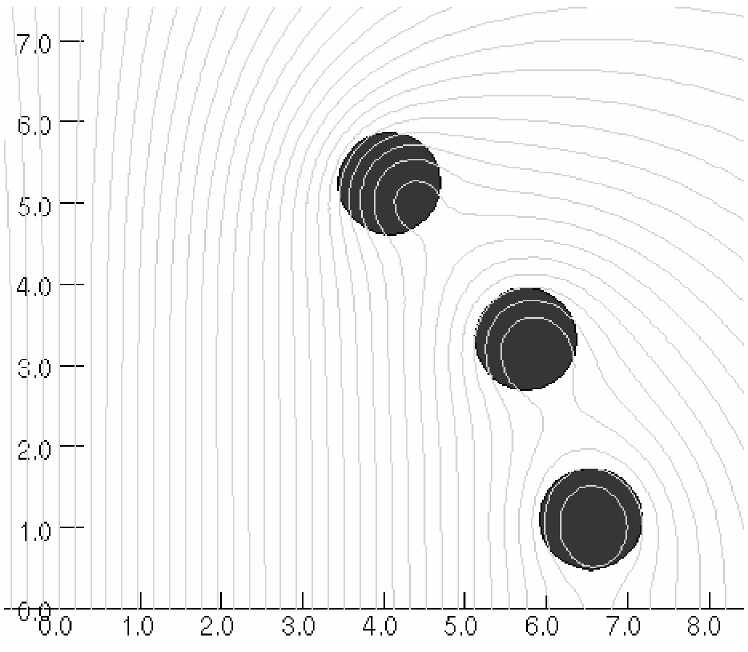
with ferrite



Io = 145.6 A
L = 60.4 μH

Cosine Theta Type – N=3 (x2)

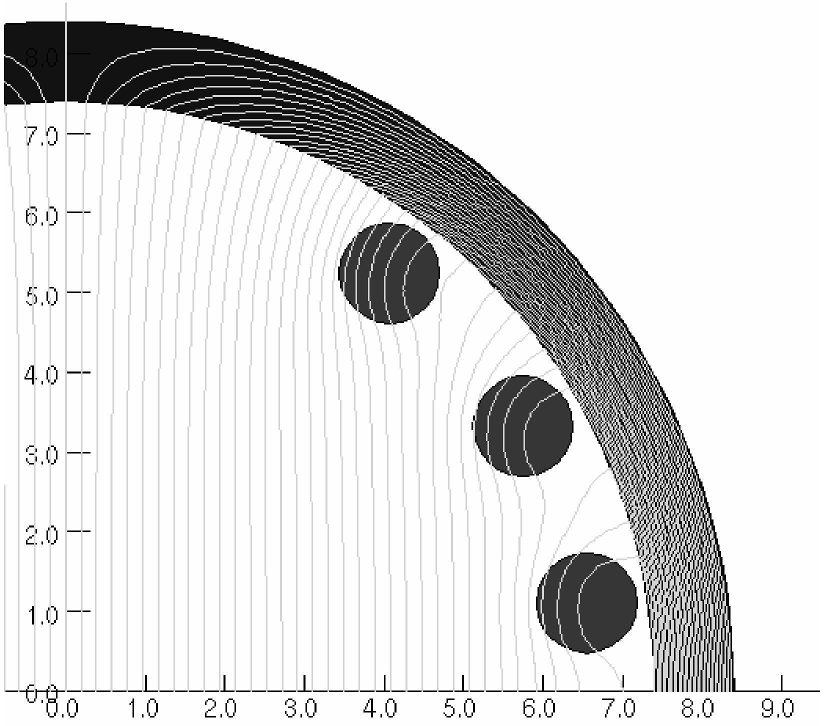
Air-coil



Io = 350.7 A

L = 18.8 μH

with ferrite

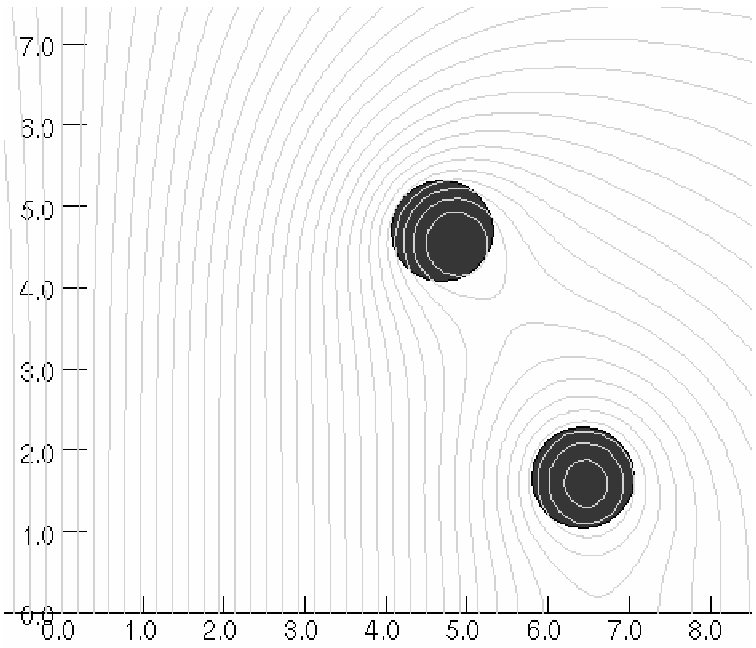


Io = 192.9 A

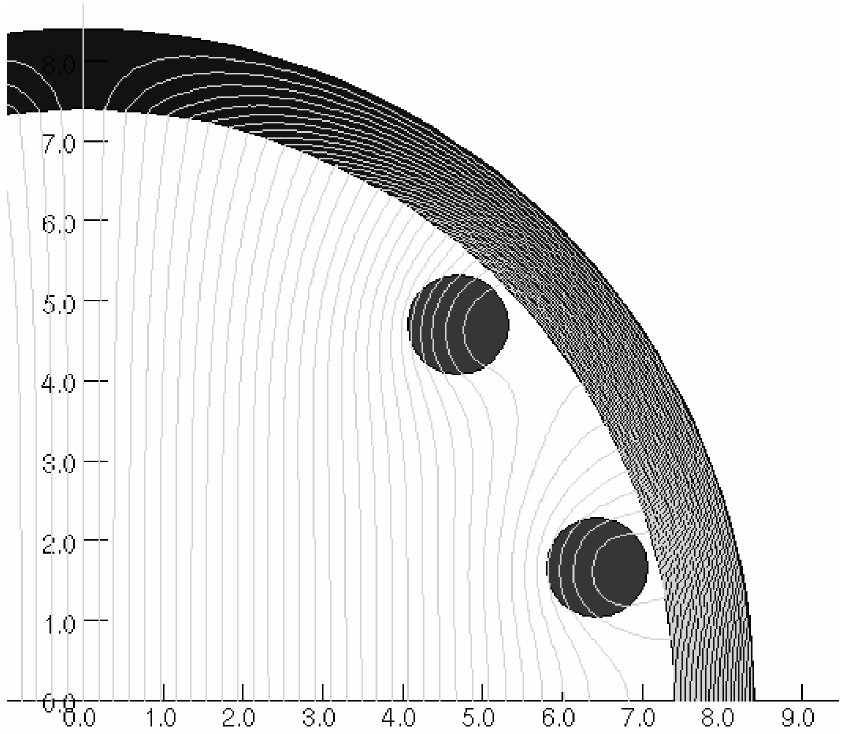
L = 34.8 μH

Cosine Theta Type – N=2 (x2)

Air-coil



with ferrite



Io = 517.3 A
L = 9.2 μH

Io = 284.5 A
L = 16.7 μ H

Summary --

(1) All the cases above (except cosine 7-turn one-layer) same conductors are used (as existing one: d=0.5”), tentatively

(2) Ferrite shell reduces current by a factor of ~ 0.52-0.55; increases inductance by a factor of ~ 1.9; it gives slightly better field, and will make internal field stable in the tunnel

(3) Information needed for next iteration based on optimized resonant impedance ---

a. Number of turns;
b. Real conductor size (with associated J and R);
c. Preference: with/without Ferrite shell.